Similarity Analysis: Comparison of a Standard 60mL With an Anti-Static Container for MicroCT

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Executive Summary

Pursuant to safety concerns, an anti-static container has been proposed for holding specimen materials scanned by an International Partner (IP) on a MicroCT system. In order to determine whether or not this new container would significantly affect MicroCT results, a similarity analysis procedure developed at LLNL was used[1]. This procedure compares multiple first and second order statistics obtained from CT reconstructed images generated by the MicroCT analysis process, and prescribes similarity constraints as guidance. For this study, water was scanned on a MicroCT system in both a standard container and the proposed anti-static container under Test Plan 83[2]. Data were analyzed following the Standard Operating Procedure (SOP) for MicroCT analysis[3]. Comparison of analytical results shows that the anti-static container satisfies all similarity analysis criteria.

[1] Harry E. Martz, Jr. and Carl Crawford, *Validation of Explosive Simulants Requirement Specification, Draft Version 12,* LLNL-TR-416983, Lawrence Livermore National Laboratory, Livermore, CA 94551, October 26, 2009.
[2] William D. Brown, *TP83 – MicroCT Data Acquisition, Reconstruction and Analysis Using the IP MicroCT System*, *Version 1.1*, LLNL-TR-649192, Lawrence Livermore National Laboratory, Livermore, CA 94551, January 30, 2014.
[3] Isaac Seetho, *MicroCT: Analysis of CT Reconstructed Data of Home Made Explosive Materials Using the Matlab MicroCT Analysis GUI*, Lawrence Livermore National Laboratory, IDD-MCT-SOP-007, January 13, 2011.

Similarity Analysis Summary

Date: July 14, 2014

Author: Isaac Seetho (LLNL) _____

Typed or Printed Name *Signature*

Container 1 ID(s): Water (standard container)

Container 2 ID(s): Water (anti-static container)

Similarity Analysis Request Form:

Did not receive Similarity Analysis Request Form

Result: **Meets all criteria** / **Does not meet all criteria**
Underline One

Summary Explanation: **Water was scanned in both the standard 60mL Nalgene container used by LEDP, and also in a new anti-static bottle in response to safety concerns. The containers were scanned at 160kV and 100kV (with water BHC). Water-calibrated Livermore Modified Hounsfield Units ($LMHU_w$) were measured. All similarity analysis parameters satisfied constraints.**

Type of Validation Test *Check or Underline One*	**Source of Features for Standard Container** *Check or Underline One*
☐ **Standard container, Anti-static container**	☐ **Measured**
☐ **One object to multiple objects**	☐ **Modeled**
☐ **Multiple objects to multiple objects**	

First Order Summary Analysis: Standard container, Anti-static container

Data Set	Test	Standard ($LMHU_w$)	Anti-static ($LMHU_w$)	Relative difference(%) $\left\lvert\frac{Antistatic - Standard}{Standard}\right\rvert$	Similar Criterion (%)	Meets Criterion
LAC–100 Al	Mean Value	1387	1387	0.06%	≤ 1	Yes
	Std. Dev.	18	18	0.58%	≤ 20	Yes
	Entropy	4.3	4.3	0.14%	≤ 8	Yes
	KDE Similarity	98.1			≥ 88	Yes
LAC–160 AlCu	Mean Value	1013	1012	0.11%	≤1	Yes
	Std. Dev.	19.8	19.7	0.22%	≤ 20	Yes
	Entropy	4.4	4.4	0.05%	≤ 8	Yes
	KDE Similarity	97.8			≥ 88	Yes
Observations	Texture in LAC-160 slice	Qualitatively Similar: (Underline one) Yes / No				
	Viscosity	Qualitatively Similar: (Underline one) Yes / No				
	Moldability	Qualitatively Similar: (Underline one) Yes / No or NA				

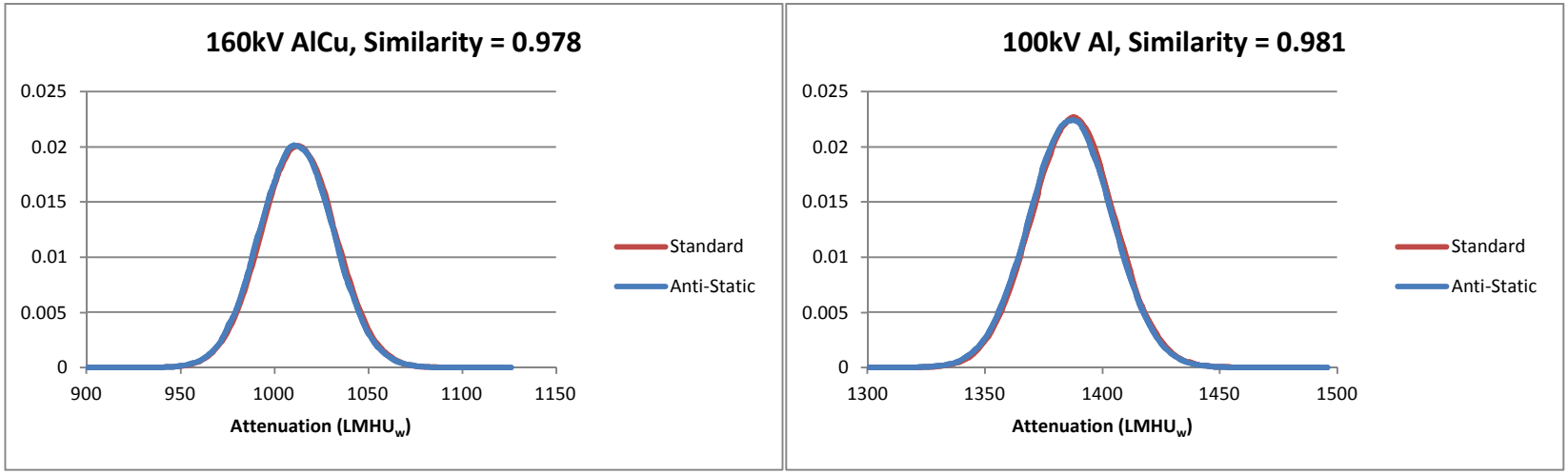
Second Order Summary Analysis: Standard container, Anti-static container

Difference image (DX) Data Set	Test	Standard ($LMHU_w$)	Anti-static ($LMHU_w$)	Relative difference(%) $\left\|\frac{Antistatic - Standard}{Standard}\right\|$	Similar Criterion (%)	Meets Criterion
LAC–100 Al	Mean Value	16	16	0.32%	≤ 5	Yes
	Std. Dev.	12	12	0.58%	≤ 5	Yes
	Entropy	3.8	3.8	0.10%	≤ 5	Yes
	KDE Similarity	99.6			≥ 88	Yes
LAC–160 AlCu	Mean Value	18	18	0.16%	≤5	Yes
	Std. Dev.	13	13	0.13%	≤ 5	Yes
	Entropy	3.9	3.8	0.06%	≤ 5	Yes
	KDE Similarity	99.4			≥ 88	Yes
Observations	Texture in LAC-160 slice	Qualitatively Similar:		(Underline one)	Yes / No	

Supplemental Analysis — Standard container, Anti-static container

Other Supporting Data:

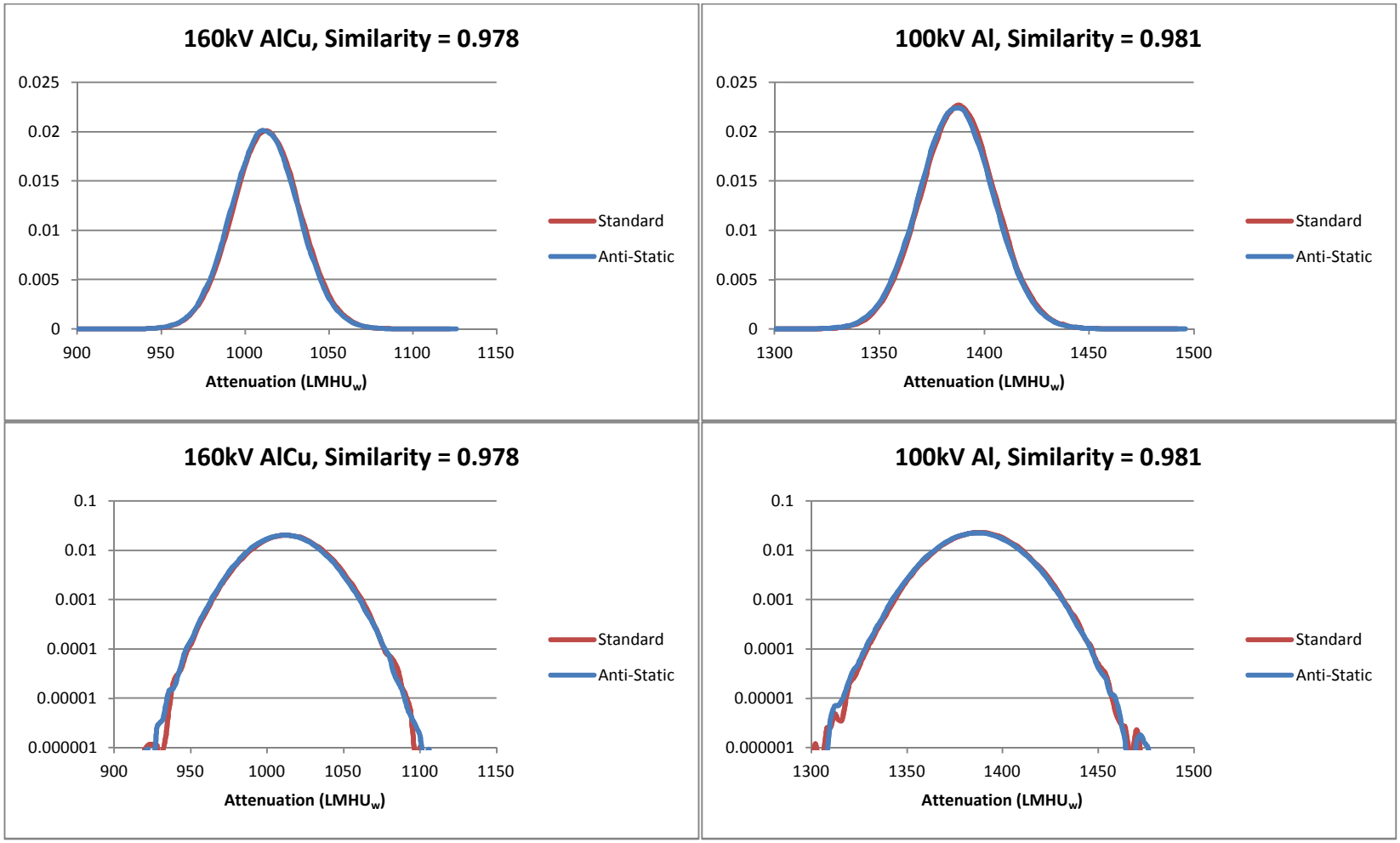
1. **Graphs of Kernel Density Estimation (KDE) functions**
   a. **First order statistics**



All values meet criteria.

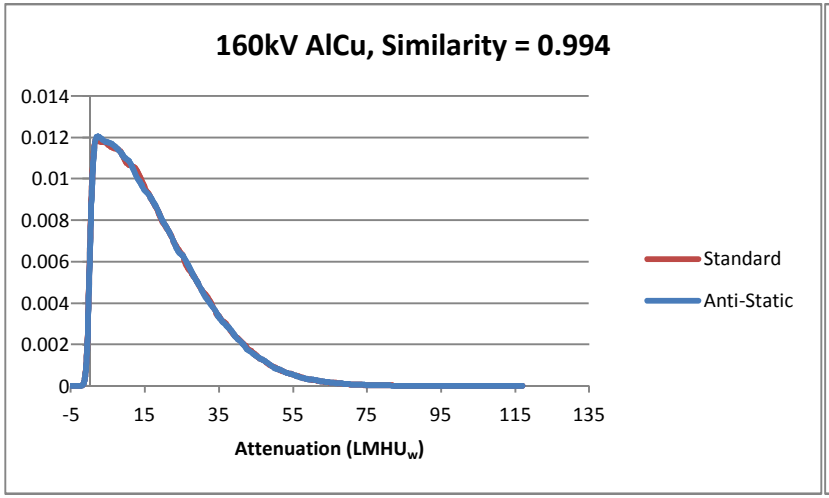
160kV	Standard	Antistatic	% Dev
Mean:	1012.87	1011.80	0.11%
Std Dev	19.76	19.72	0.22%
Entropy	4.41	4.40	0.05%
100kV	**Standard**	**Antistatic**	**% Dev**
Mean:	1387.47	1386.67	0.06%
Std Dev	17.64	17.74	0.58%
Entropy	4.29	4.30	0.14%

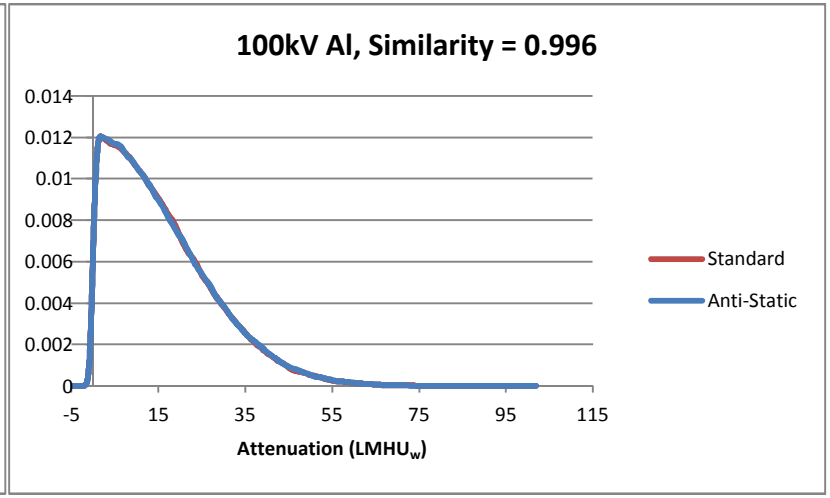
b. First order linear (top) and semi-log (bottom) density functions



The log plot emphasizes the similarity between the anti-static and standard bottle's distributions.

c. **Second order statistics**

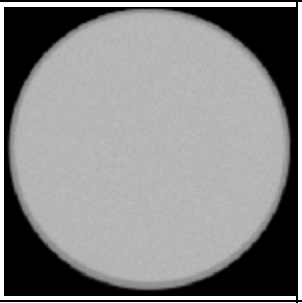
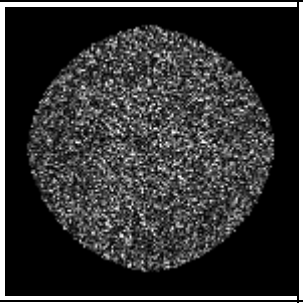
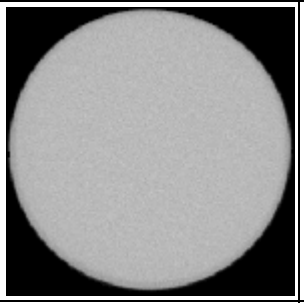
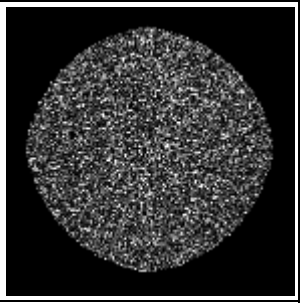
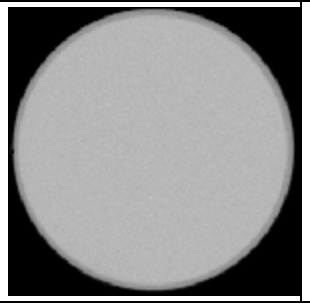
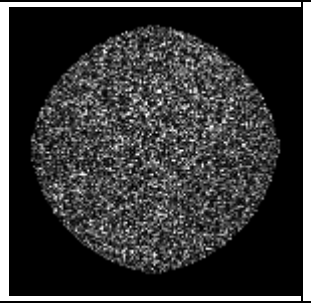
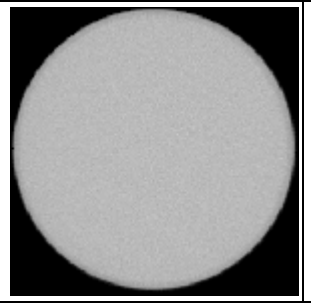
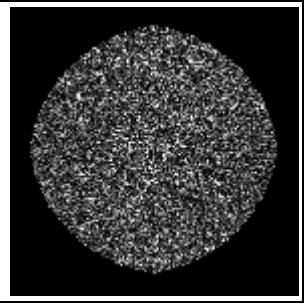




All values meet criteria.

160kV	Standard	Antistatic	% Dev
2nd mean	17.53	17.51	0.16%
2nd std	13.29	13.28	0.13%
2nd entropy	3.85	3.85	0.06%
100kV	**Standard**	**Antistatic**	**% Dev**
2nd mean	15.87	15.92	0.32%
2nd std	12.03	12.10	0.58%
2nd entropy	3.75	3.76	0.10%

2. **Photos**
   a. **Anti-static container: None available**
   b. **Material(s): None available**
3. **Screen shots of x-ray images Water in standard container and anti-static container**

	100kV Al	100kV Al DX*	160kV AlCu	160kV AlCu DX
Standard				
Anti-static				

***DX images show gradient taken after segmentation and erosion.**
Visually, the two scans are indistinguishable.

Summary of Data Used for Analysis

Container 1 (TP83: 140302_Water_Regular_Bottle)

ID	Provided by	Date Obtained	Date x-rayed	X-rayed at	X-rayed by	Data sent to LLNL to	On LEDP server
Water	IP	3-2-2014	3-2-2014	IP	IP	Bill Brown	7-3-2014

Container 2 (TP83: 140302_Water_AntiStatic_Bottle)

ID	Provided by	Date Obtained	Date x-rayed	X-rayed at	X-rayed by	Data sent to LLNL to	On LEDP server
Water	IP	3-2-2014	3-2-2014	IP	IP	Bill Brown	7-3-2014

Experimental Measurements

Material Sample ID	Date	Radiologist	Slits	kVp	mA	Al Filter (mm)*	Cu Filter (mm)*	Directory
140302_Water_Regular_Bottle	3-2-14	IP	2	100	7	2.0	N/A	X:\TP83_MicroCT_Data_Acquisition_XX\XX\None\MicroCT\None\140302_Water_Regular_Bottle\Exp2
	3-2-14	IP	2	160	4.35	2.0	2.0	X:\TP83_MicroCT_Data_Acquisition_XX\XX\None\MicroCT\None\140302_Water_Regular_Bottle\Exp1
140302_Water_AntiStatic_Bottle	3-2-14	IP	2	100	7	2.0	N/A	X:\TP83_MicroCT_Data_Acquisition_XX\XX\None\MicroCT\None\140302_Water_AntiStatic_Bottle\Exp2
	3-2-14	IP	2	160	4.35	2.0	2.0	X:\TP83_MicroCT_Data_Acquisition_XX\XX\None\MicroCT\None\140302_Water_AntiStatic_Bottle\Exp1

*** Not in sct file, values confirmed in data acquisition test plan.**

1. **Antistatic container preparation**

Person responsible:	IP Personnel
Date/time put into container:	Unknown
Location:	International Partner
Identifier:	Water (Antistatic Bottle)
Digital picture:	N/A
Preparation procedure:	N/A
Containment:	Anti-static Bottle
Observations:	Transparent colorless liquid

2. **Standard container preparation**

Person responsible:	IP Personnel
Date/time put into container:	Unknown
Location:	International Partner
Identifier:	Water (Regular_Bottle)
Digital picture:	N/A
Preparation procedure:	N/A
Containment:	60 mL LDPE Nalgene Bottle
Observations:	Transparent colorless liquid

3. **Antistatic container scanning**

Person responsible:	IP Personnel
Date/time acquired:	3-2-2014
Location:	International Partner
Scan description:	Water (Antistatic_Bottle)
Observations:	
Date and time sent to LLNL:	Unknown

4. **Standard container scanning**

Person responsible:	IP Personnel
Date/time acquired:	3-2-2014
Location:	International Partner
Scan description:	Water (Regular Bottle)
Observations:	
Date and time sent to LLNL:	Unknown

5. Reconstruction: Standard container

Reconstructed by: Isaac Seetho
Date: 7-3-2014
Location: LLNL B327 R1280
Computer: HP Z210 Workstation
Reconstruction Software:
Software: Imgrec
Version: 2.8.7.12c17
Script Files:
Directory:
X:\TP83_MicroCT_Data_Acquisition_XX\XX\None\MicroCT\None\140302_Water_Regular_Bottle\Exp1
X:\TP83_MicroCT_Data_Acquisition_XX\XX\None\MicroCT\None\140302_Water_Regular_Bottle\Exp2
Files: 140112_Script_Exp1.txt and 140112_Script_Exp2.txt
Raw Data Files: Exp1_*nn*.sdt, Exp2_*nn*.sdt (*nn* denotes image number from 0-399).
Reconstructed Files: recobj_26 to 36

6. Reconstruction: Antistatic container

Reconstructed by: Isaac Seetho
Date: 7-3-2014
Location: LLNL B327 R1280
Computer: HP Z210 Workstation
Reconstruction Software:
Software: Imgrec
Version: 2.8.7.12c17
Script Files:
Directory:
X:\TP83_MicroCT_Data_Acquisition_XX\XX\None\MicroCT\None\140302_Water_AntiStatic_Bottle\Exp1
X:\TP83_MicroCT_Data_Acquisition_XX\XX\None\MicroCT\None\140302_Water_AntiStatic_Bottle\Exp2
Files: 140112_Script_Exp1.txt and 140112_Script_Exp2.txt
Raw Data Files: Exp1_*nn*.sdt, Exp2_*nn*.sdt (*nn* denotes image number from 0-399).
Reconstructed Files: recobj_26 to 36

7. Analysis

Person responsible: Isaac Seetho
Date: 7-3-2014
Location: LLNL B327 R1280
Segmentation/ROI: Used automated snakes and erosion
Filename(s): Automated MicroCT Analysis v1.3_MCTTB
Observation(s): N/A